Preliminary Design of the Motion Box for the CUORE DCS

- Status and Open Issues -

March 26, 2008

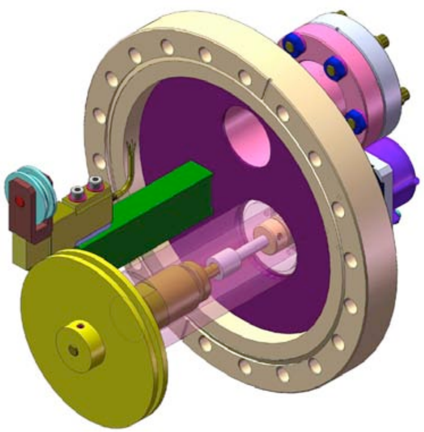
Some Design Requirements of DCS Motion Box

- 12 sources to be deployed through 4 ports on 300K flange
- positioning accuracy of source carrier inside cryostat: < 5mm
- vacuum motion boxes with max pressure of $< 10^{-6}$ torr
- ability to exchange individual sources in motion box
- ability to maintain motion system and exchange sources without disturbing cryostat
- ability to deploy different radioactive isotopes
- high-reliability of motion system
- expected livetime of motion system: > 5 years
- interlocks and fail-safe mechanisms to avoid
  - loss of source in cryostat
  - contaminating cryostat
  - compromising cryostat vacuum

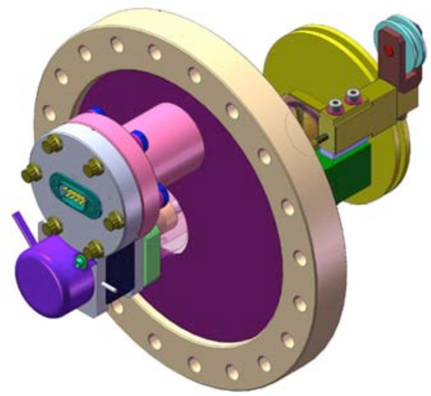
DCS Motion Box - Overview

- 3 power trains/spools per motion box
- 4 motion boxes for a total of 12 sources

Drive Flange

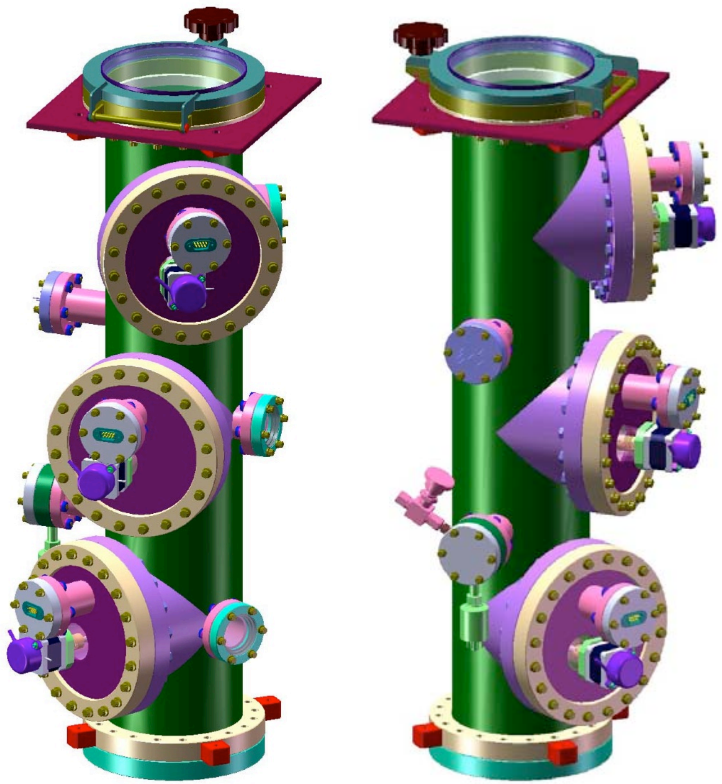


inside view

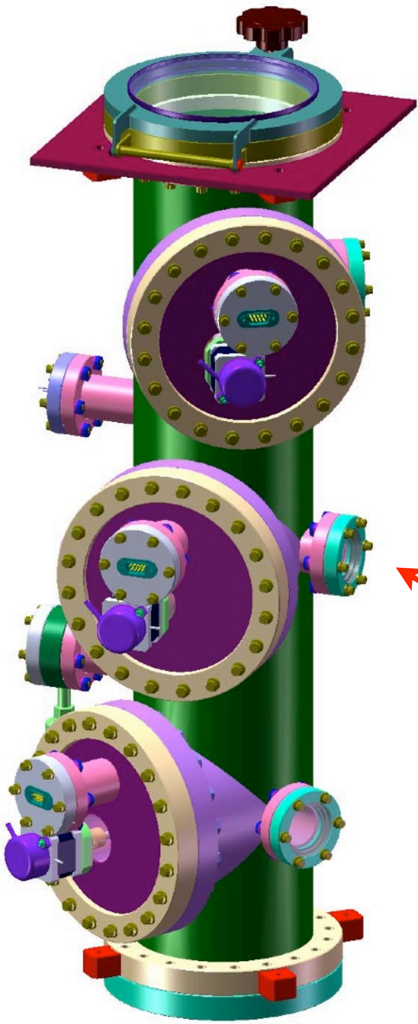


outside view

Motion Box
- contains 3 drive flanges

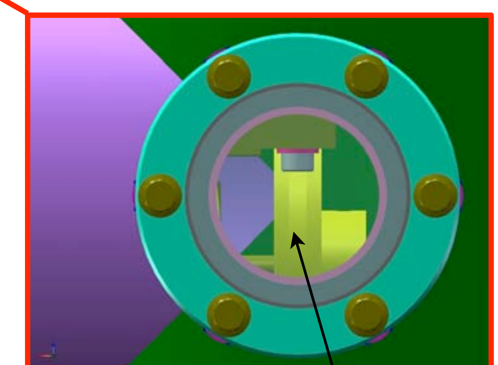


DCS Motion Box - Overview



iso view

top view



spool

individual viewport

- will see top of spool, descending source string

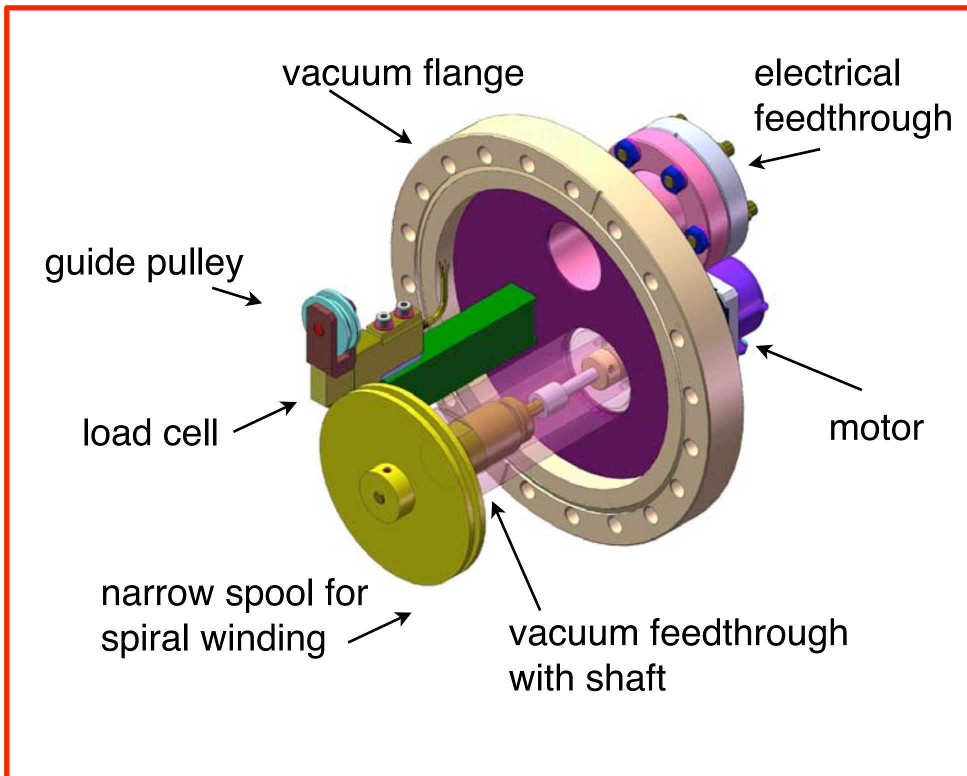
- position of viewport will be optimized

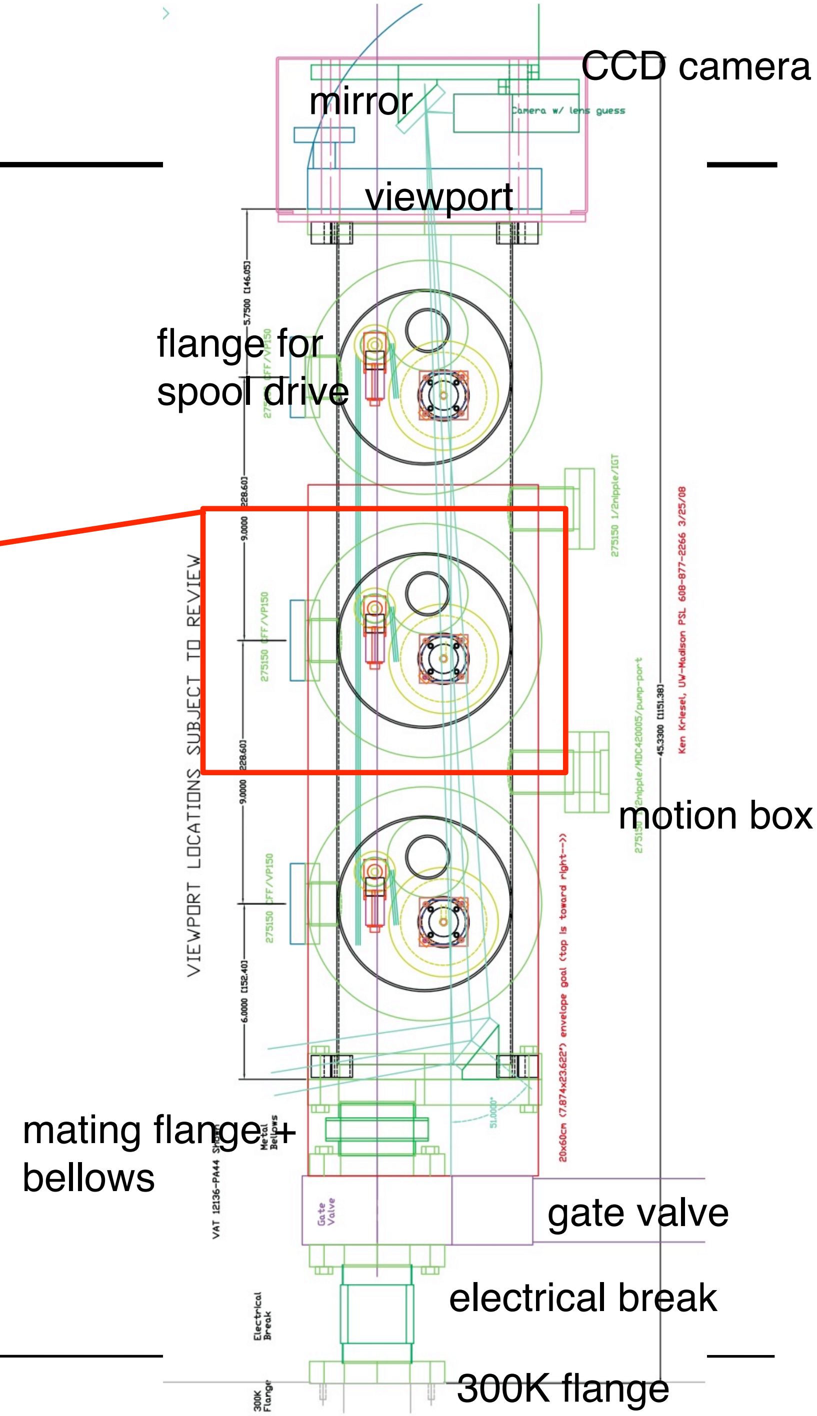
weight of motion box assembly: ~ 65kg

DCS Motion Box - Overview

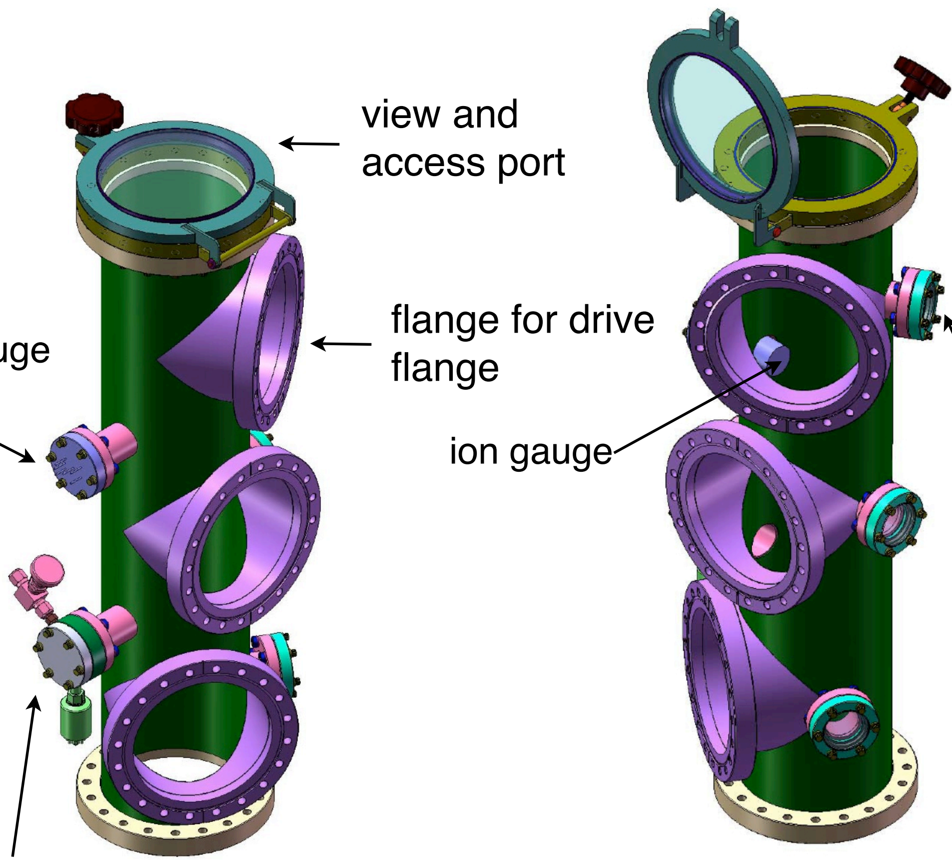
- 3 spools per motion box
- 4 motion boxes for a total of 12 sources

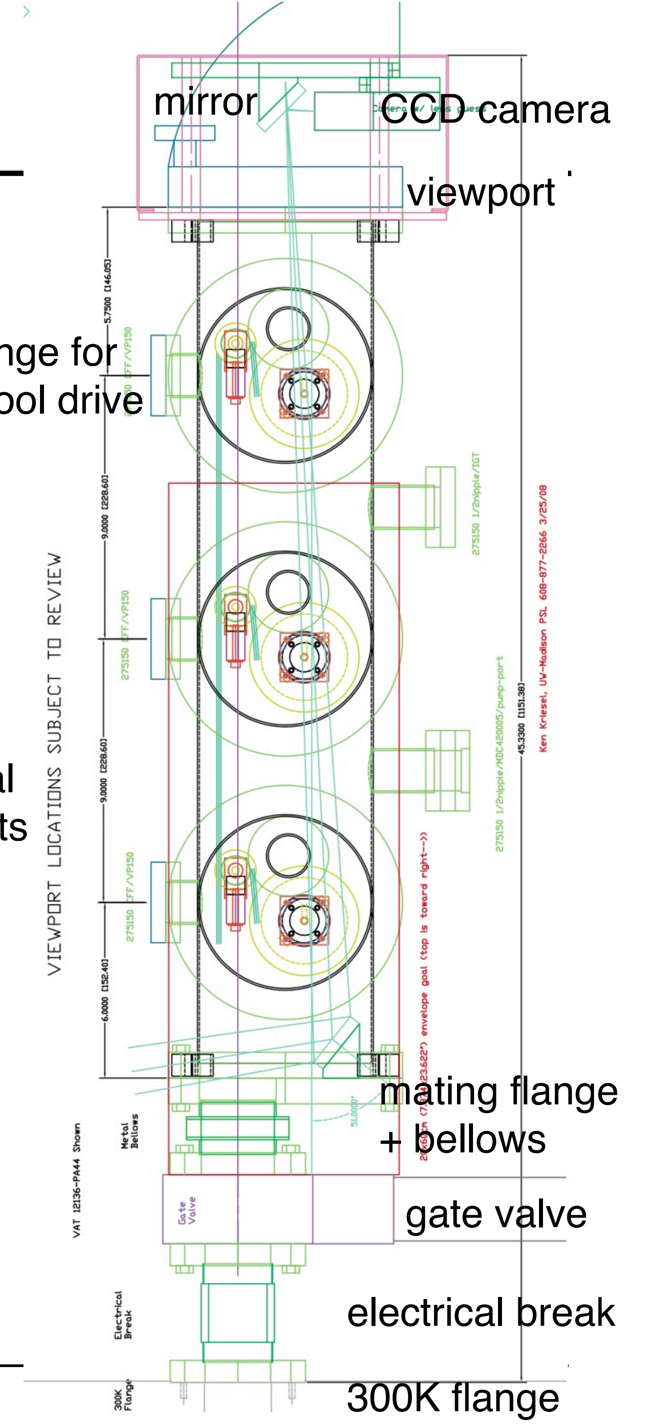
each drive flange can be removed individually from motion box





DCS Motion Box - Features

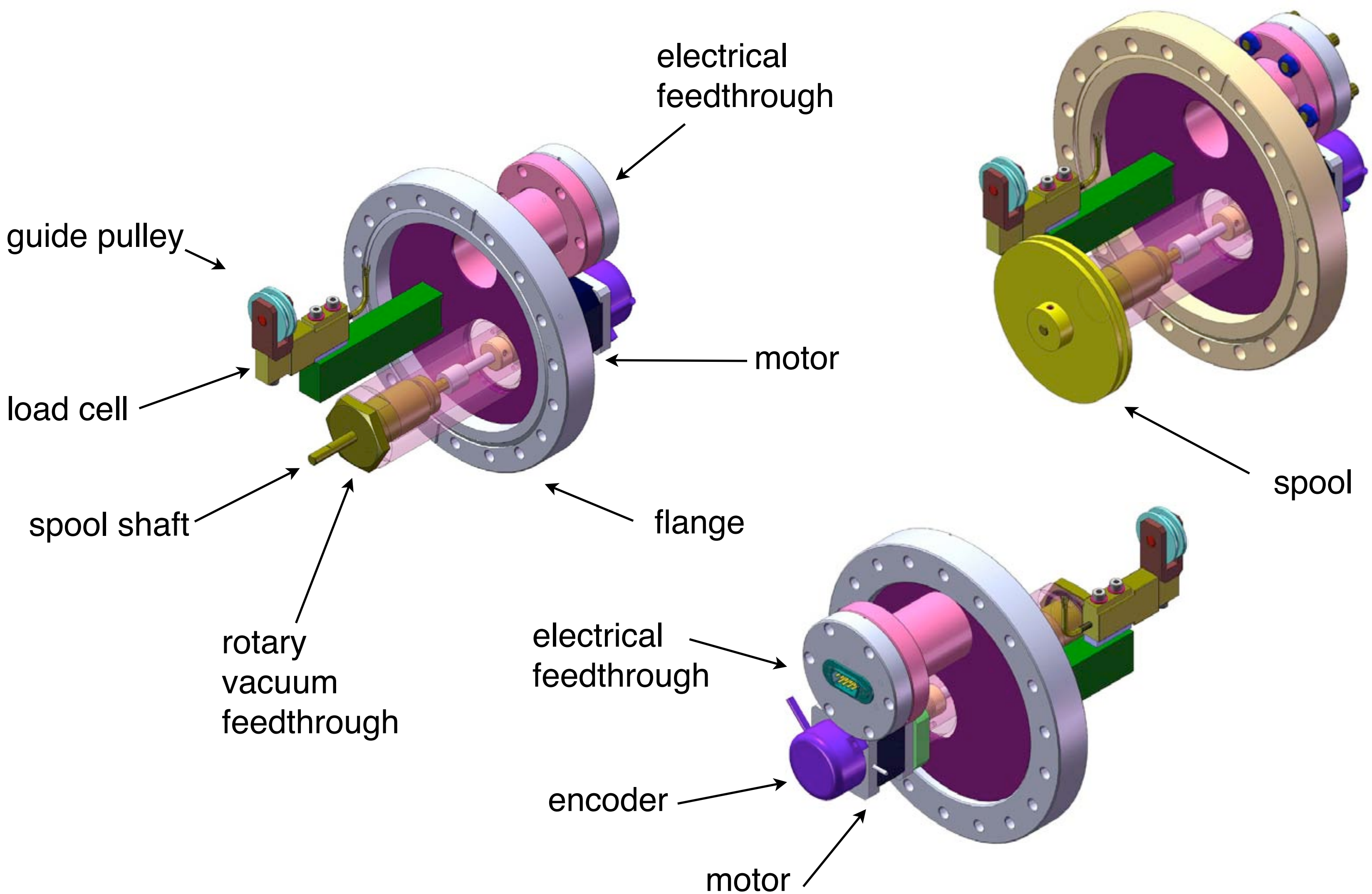




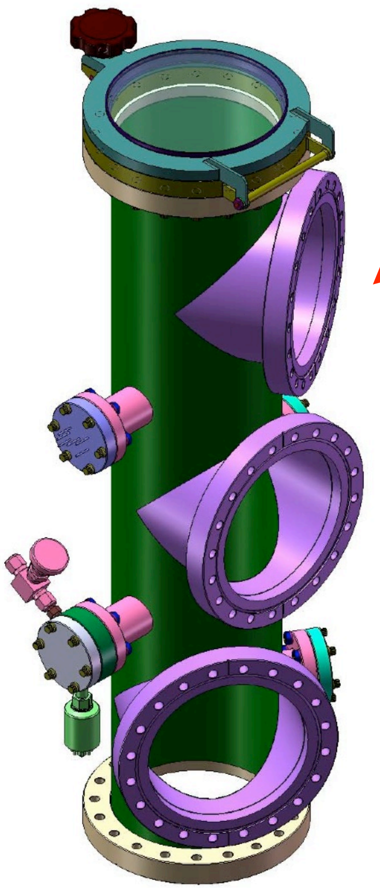
Questions:

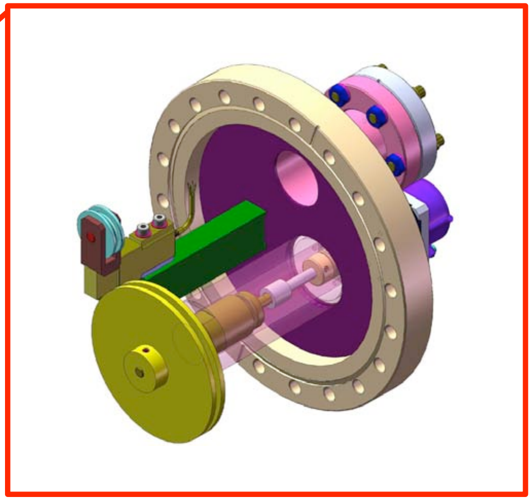
- do we need to T-off ion gauge to avoid line of sight into cryostat?
- spare ports on motion box?

DCS Motion Box - Drive Flange



DCS Motion Box - Modular Assembly





- each drive train is a self-contained unit

- each drive train can be removed from the motion box for maintenance, repair, or source exchange

- gaskets for the drive flanges can be Viton (with or without retaining ring) or metal gasket

Elements Not Yet Shown in 3D Model

1. CCD camera + mirror
2. light box and mount for camera
3. lifting lugs on top of motion box
4. electrical isolation to 300K flange
5. vibration isolation to 300K flange
6. gate valve
8. valve and pump connections
9. spare ports
10. rear motor shaft for emergency retrieval

Vacuum Seals in Motion Box

Seal Count per 3-drive Motion Box

static
1 gate valve to bellows
1 bellows to chamber
1 chamber top flange to viewport hatch
1 hatch seal
3 side viewports
3 drive flanges
3 drive electrical fdthru flanges
3 under rot fdthru nut on body
6 at purge/tc/rough port
1-3 proximity sensors (may be more than one)
1 ion gauge
(subtotal 24-26)

dynamic
- 3 rotating drive shafts (o-ring or ferrofluid)

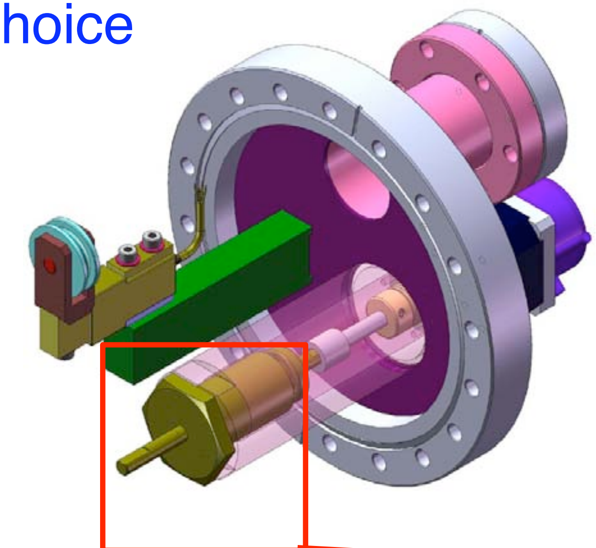
TOTAL
(per 12 installed strings, or 4 drive chambers)

96-104	static seals
12	dynamic seals

Baseline:
Viton gaskets. Can change to metal gaskets if necessary.

Rotating, Dynamic Seal of Spool Shaft

Baseline Choice



> almost stationary application:
(< 30 turns per calibration, calibration every 2 months, 5 year livetime
< 1000 rotations in 5 years)

Viton-Based Seal

http://www.mdcvacuum.com/urd/uniface.urd/ecf0070w.display?7.1.1.7

- Viton® elastomer shaft seal
- Bakeable to 100°C
- 1x10-8 Torr

> seal can go to ~ 10^-8 torr

Options for Rotating, Dynamic Seal of Spool Shaft

Viton-Based

http://www.mdcvacuum.com/urd/uniface.urd/ecf0070w.display?7.1.1.7

- Viton® elastomer shaft seal
- Bakeable to 100°C
- 1x10-8 Torr
- cost: $380.00

Ferrofluid-Sealed Rotary Feedthrough

http://www.ancorp.com/line.aspx?id=247&catid=13

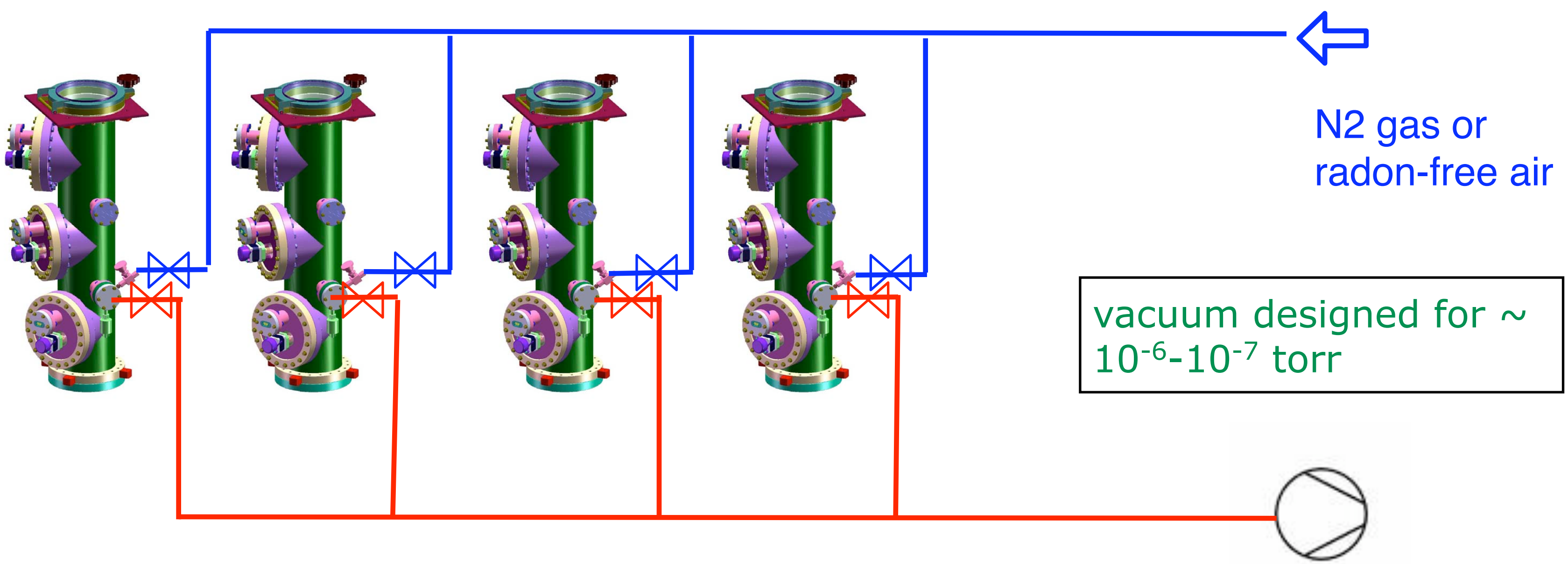
- Vacuum rated to 1×10^{-8} torr (UHV option rated to 1×10^{-9} torr)
- Hermetically sealed with the Rigaku SuperSeal™ ferrofluid technology
- Bake temp limit is 80C
- cost: $480.00

> non-viton rotary seal would require some re-design of drive flange

DCS Vacuum System and Operation

Proposed Vacuum System & Operation

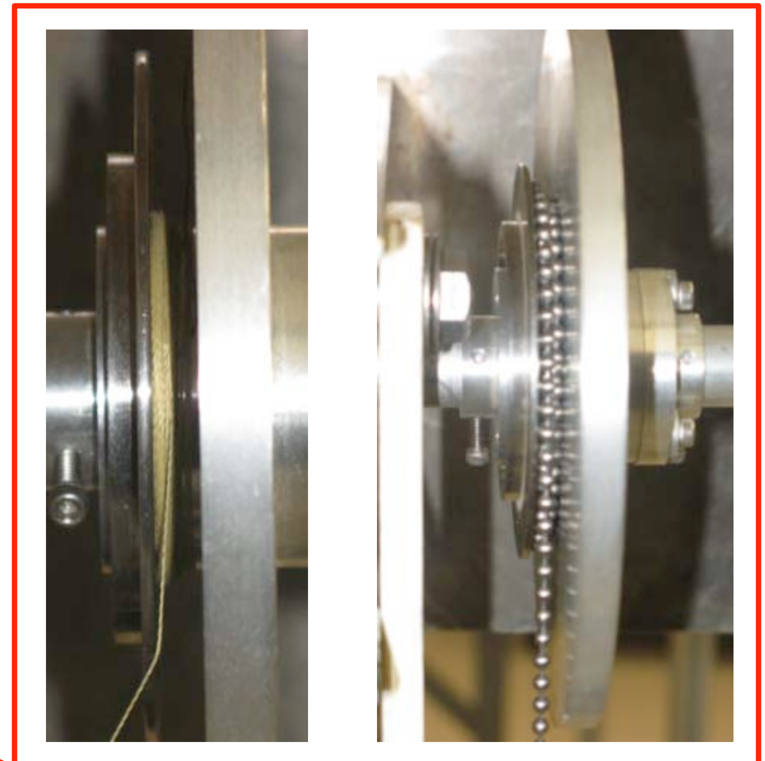
- one pump station for all 4 motion boxes
- N2 purge gas for bringing motion boxes up to atmopsheric pressure
- manual valves for vacuum and gas control
- leave pumps running during operation of DCS and while gate valves are open



Questions:
- where can we locate pump station?
- do we need vibration isolation of pump line from cryostat?

Spool Design and Winding of Source Carrier

Spool design and dimensions very much depend on source carrier. Source carrier design still being finalized.

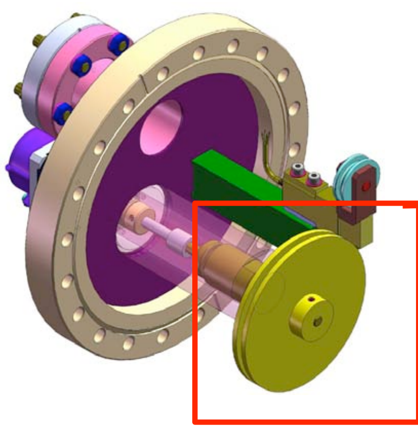


Baseline Design

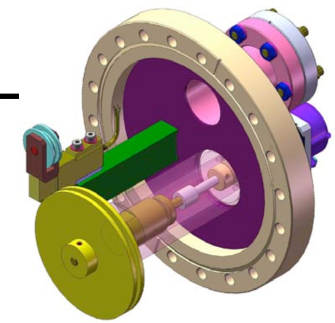
- multi-layer, spiral winding on narrow spool

- diameter of spool approximately 3” (as large as possible within integration constraints)

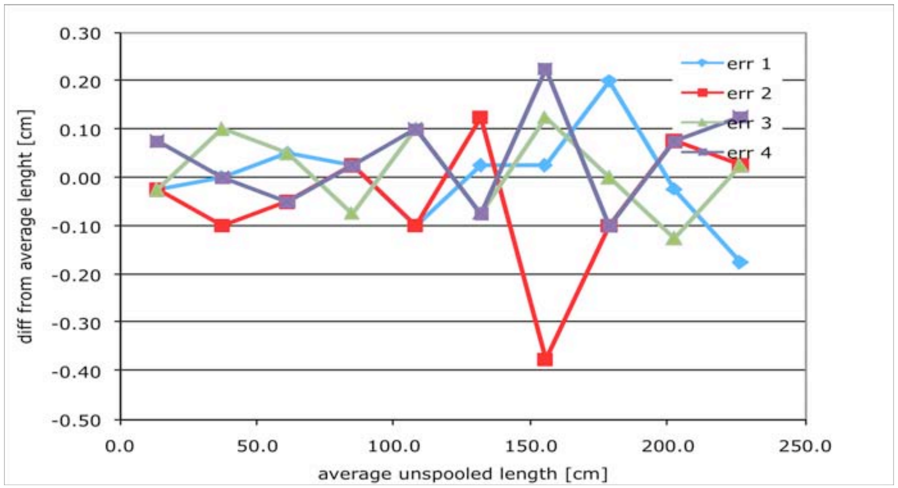
- width of spool ~ size of balls or other source carriers



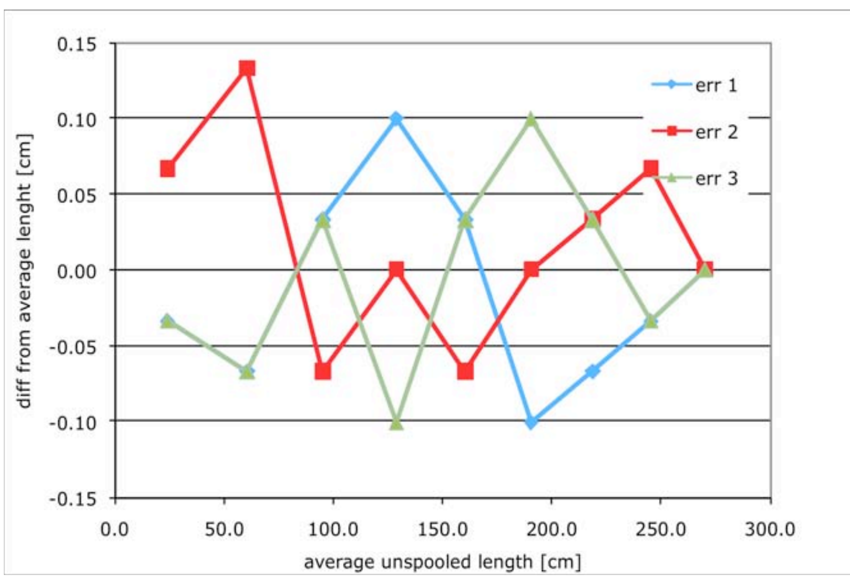
Spool Design and Source Carrier Winding



Positioning Accuracy:
Winding tests with narrow, large-diameter spool



kevlar string on 7.5 cm spool dia
and 3.4mm width with string feeder



ball chain on 7.5 cm spool dia
and 3.7mm width

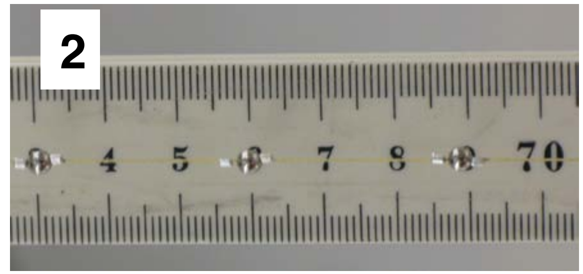
positioning accuracy: < 5mm

Spool Design and Winding of Source Carrier

Alternative Designs

Source Carrier Options:

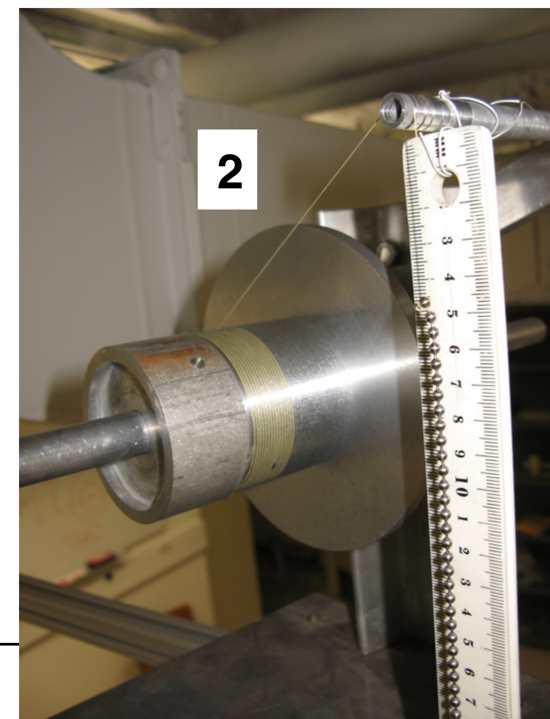
1. string + ball chain
2. individual balls on string
3. string + cylindrical source containers



Winding and Spool Options:

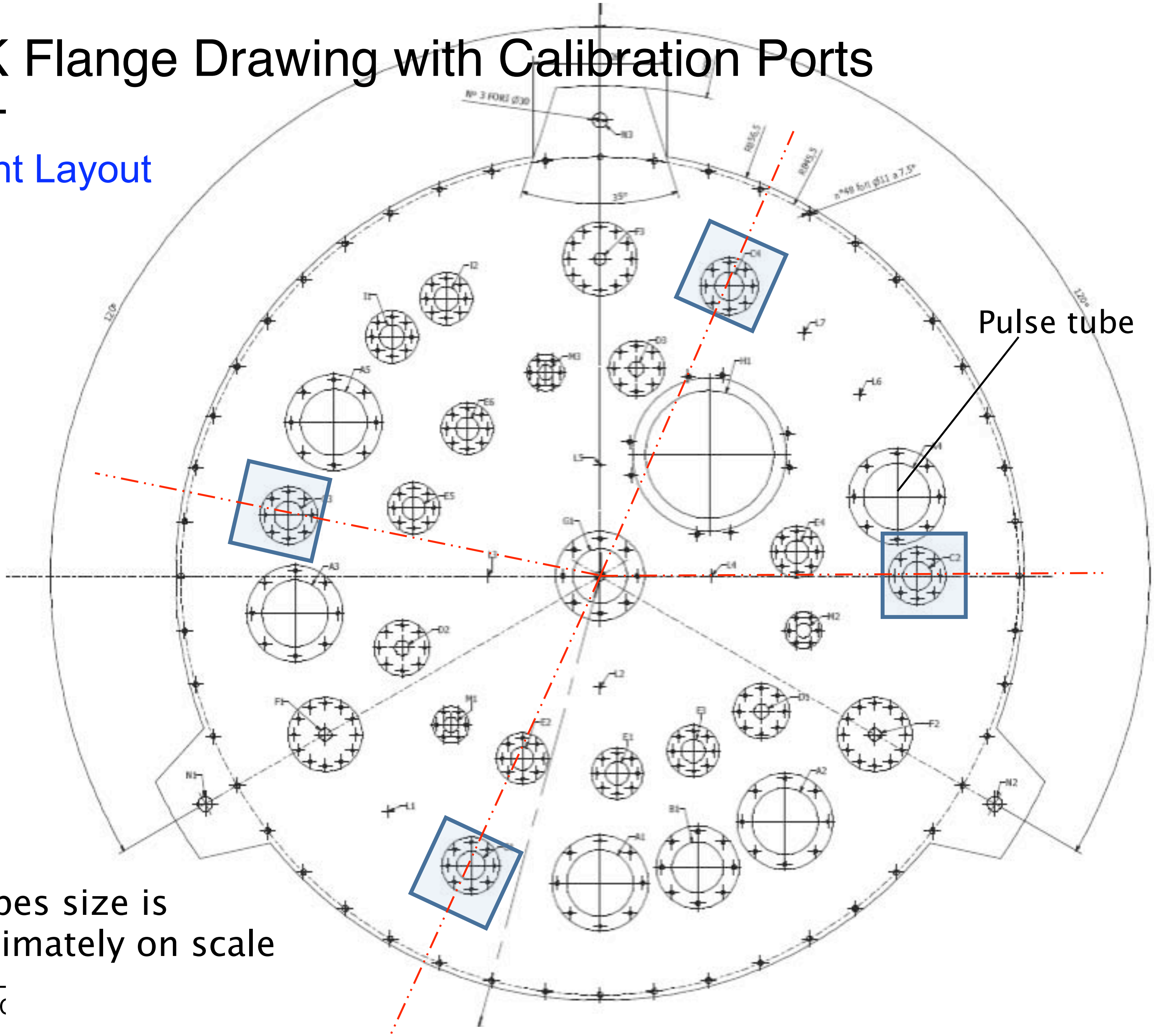
1. multi-layer, spiral winding on narrow spool

2. single-layer, grooved winding on wide spool



300K Flange Drawing with Calibration Ports

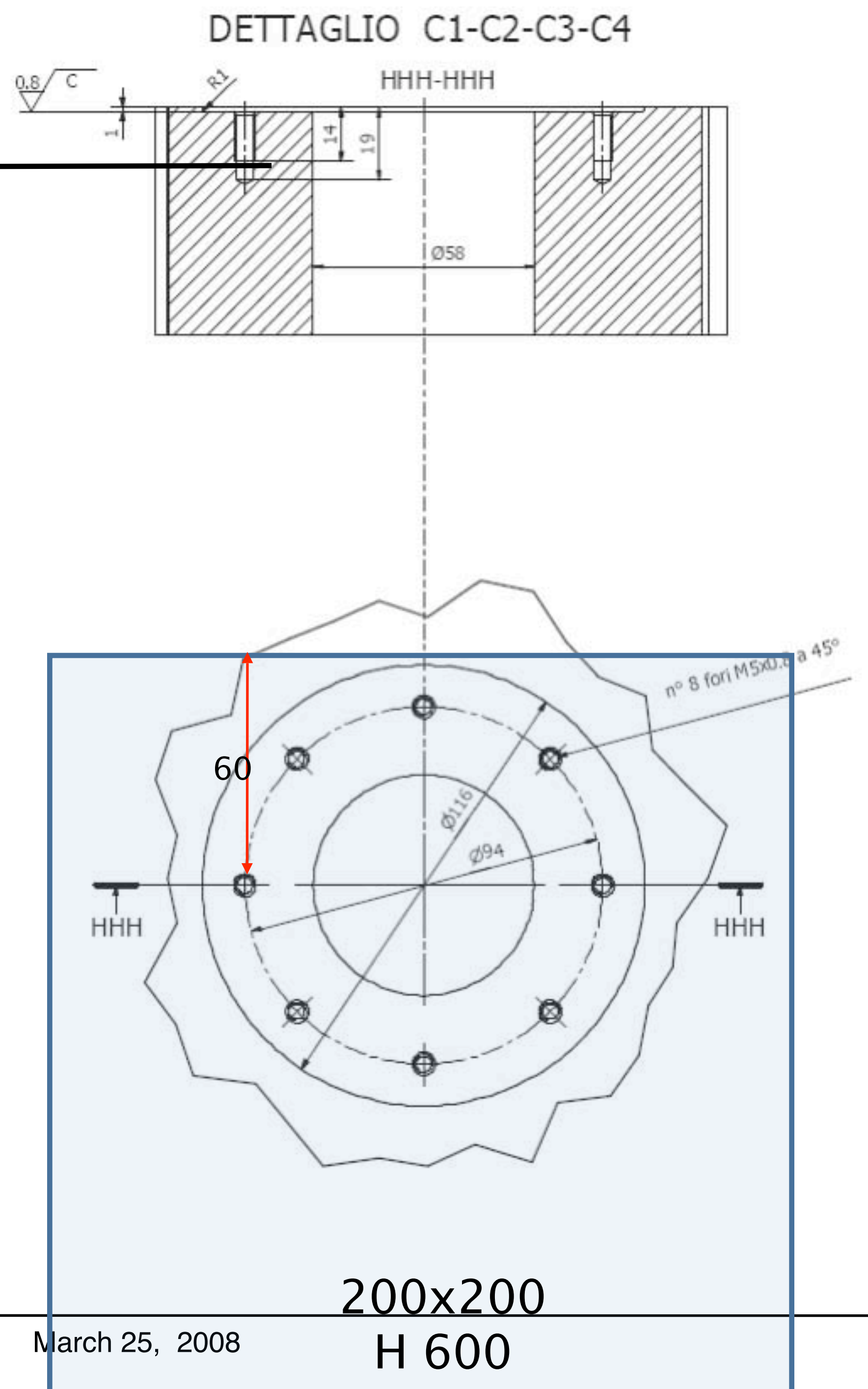
Current Layout



envelopes size is approximately on scale

Calibration Ports

Current Layout



Envelope is not centered
on the hole in the flange

Questions&Open Issues

In approximate order of priority

1. define interface flange design on 300K flange (ISO, ASA, etc,) ?
2. electrical isolation of motion box from 300K flange?
3. vibrational isolation of motion box from 300K flange?
4. review integration envelop (height, width, orientation)
5. finalize spool and source carrier design
6. where can we locate pump station?
7. do we need vibration isolation of pump line from cryostat? can we vacuum pump running during normal cryostat operation and while the calibration sources are deployed?
8. is helium diffusion through viton O-ring seals an issue for the cryostat (if we shut off the pump)? Do we need all metal gaskets in the motion box?
9. do we need to T-off ion gauge to avoid line of sight into cryostat?
10. spare ports on motion box?
11. do we want to use differential pumping on the rotating shaft seals?
12. do we need to be able to open top viewport? Can we replace it by fixed window?